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Mechanisms and timescales of porous melt flow driving weakening and exhumation of deeply subducted continental crust

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Weakening of rocks by interstitial melt plays a significant role in the dynamics of orogenic systems. The microscale to mesoscale mechanisms responsible for melt enhanced weakening and melt transfer in high pressure anatectic rocks are still a matter of debate. To address the mechanisms and timescales of coupled melt migration and deformation in high pressure conditions, we have focused on a section of continental crust that was subjected to continental subduction in the Variscan Bohemian Massif. The section reveals anatectic banded orthogneisses interlayered with migmatitic granofelses and granulites within a single deformation fabric related to the prograde metamorphism. Pressure-temperature conditions for the banded orthogneiss were estimated at 9 kbar and 700°C, while granofels and granulite reveal much higher pressures of 15 kbar at 760°C, and 15-16 kbar at 775-840°C, respectively. We show that the granofels layers represent high strain zones and reveal traces of localized porous melt flow that infiltrated the host banded orthogneisses and crystallized melt in the grain interstices. This is supported by enrichment in uranium, thorium and cesium in the migmatites and loss of these elements in the granofelses and granulites, although major element composition and zircon ages of all these rock types remain similar. We propose that the through going porous melt flow promoted metamorphic equilibration of the anatectic rocks at progressively increasing metamorphic conditions and resulted in significant weakening of the anatectic sequence. Core to rim trends in monazites from the granulites and granofelses reveal increasing Yb/Gd, compatible with decreasing core-rim trend of Yb/Gd in garnet, and suggest a crystallization of the monazite rims on a retrograde path associated with incipient exhumation of the system. Corresponding ages reveal time span of about 5 million years between the peak prograde metamorphism (350 Ma) of the granulites and granofelses and their incipient exhumation (345 Ma). Youngest ages of the monazite rims in the migmatites of 335 Ma thus bracket the entire duration of the metamorphism coupled with reactive porous melt flow between the 'source' granulites and 'sink' migmatites at 15 Ma years.